SPOUTED BED GASIFICATION OF WESTERN CANADIAN COALS

FINAL REPORT 1980-81

DSS File No. 20SU-23440-0-9125
Contract Serial No. OSU-00068

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April 1981

MAR 3 1986
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ABSTRACT

The report describes the work done on the CANMET project, Spouted Bed Gasification of Western Canadian Coals, during the year 1980-81. Experimental results on the spouted bed pilot unit are discussed relating to disposition of sulphur in the coal, recycle of char from the cyclone, use of char versus inert bed and the gasification of high surface moisture coal. Complete data on two extended runs lasting 14 and 11 hours are reported and compared with the data of previous long runs. Future modifications necessary on the pilot unit are mentioned.

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1. INTRODUCTION

This report describes the development work during the third year of the Project 01SU 23440-7-90 of the Canadian Coal Conversion Programme, sponsored by CANMET. The main objective of this programme was to investigate the usefulness of a spouted bed gasifier for the treatment of Western Canadian coals. The general objective of the overall project were to

(i) build a 0.30 m diameter spouted bed pilot unit for coal gasification

(ii) determine optimum operating conditions for the gasification of different types of coal

(iii) demonstrate technical feasibility by extended experimental runs

(iv) gather data on the effects of operating variables necessary for scale-up

In the first year of the project item (i) was completed and some preliminary data were collected on the other items (1)*. During the second year (1979-80) certain modifications were made in the pilot unit and work was done on items (ii), (iii), and (iv). The details of this work are given in reference (2). In year three (1980-81), this work was continued. Specific objectives during 1980-81 included:

(a) to study the recycle of carryover char and its affect on carbon conversion efficiency

(b) to evaluate operation with char bed and its comparison with inert gravel bed

(c) determine the maximum moisture level in the coal which can be handled and its effect on gasifier performance

(d) assess the air pollution potential of coal gasification in a spouted bed by measuring the sulphur and particulates in the gas

(e) make more extended runs to gain confidence for scale-up

The proposed work schedule is appended to this report. The details of the work done on the above mentioned items are given below.

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* The number shown in the parenthesis relates to the reference given at the end of the report.

2. PILOT PLANT MODIFICATIONS

A number of modifications were made on the gasifier pilot plant. Some of these were to improve the operation of the unit while others were done to rectify defects and to take care of the regular wear and tear.

2.1 Coal Feed System

An Electromechanical scale (Serial No. 090579-1, manufactured by Maple Leaf Scale Co. Ltd., Vancouver) was installed on the coal feed system to obtain the weight of coal in the feeder drum continuously during a gasification run. The equipment included a digital read out (250 kg capacity), a single load cell, lever base assembly with platform, a stand for the scale and a stand for the hopper and drum. A signal conditioner system supplies the required voltage to the load cell and directs the return signal to the read out for display. It can also provide tare and balance adjustments to offset initial weight on platform. The use of automatic scale provided continuous monitoring and thus a better control on coal feed rate during gasification runs.

The pipe between the coal drum and coal feeder was straightened to minimize the possibility of plugging when handling high surface moisture coal. A deflection plate was also installed in the coal feeder drum to facilitate smoother coal movement.

2.2 Dust Recycling System

Over 90 percent by weight of the solids carried over the gas were collected in the first cyclone. So it was considered appropriate to recycle the solids collected only at the first cyclone and not to go into more complicated set up to recycle the total material collected by both the cyclones. For this purpose a rotary valve was installed on the first cyclone dust bin and the dust was then pneumatically conveyed to the bottom of the reactor.

Earlier plans to install an internal cyclone in the freeboard of gasifier to recycle the bed carryover were abandoned because of the severe restriction of headroom and space in the laboratory.

2.3 Gas Analysis

To assess the air pollution potential of coal gasification in a spouted bed it was necessary to monitor the sulphur and particulates in the gas. For quantitative estimation of sulphur gases in the product gas, a Varian (Aerographc Series 1400) gas chromatograph equipped with a flame photometric detector (Micro Tek) was used. Anderson Air Sampler (manufactured by 2000 Inc., Salt Lake City, Utah 84107, USA) Model No. 20-000 was installed in a gas

sample loop to determine the particulate loading and size distribution. These units were borrowed from other research projects for use in the coal gasification study.

As reported earlier (1,2) the product gas was analysed for its major components i.e. H_2, CO, CO_2, N_2, CH_4 and O_2 using chromatography. The previous set up employed intermittent injection and peak evaluation by manual means. It was highly time consuming and often gave doubtful results. A new data processing system, Hewlett-Packard 3388 A, was installed and programmed to sample and analyse the gas from the reactor continuously. This unit was purchased from the budget of another coal project. A few problems were encountered in maintaining a continuous flow of sample gas through the GC sampling loop. However, these were rectified by using a vacuum pump on the gas sample line.

2.4 Product Gas Incinerator

The incinerator for the disposal of gasifier product gas had always been a trouble spot in our pilot plant. Problems had been experienced in maintaining the pilot burner flame on the incinerator when the product gas enters the incinerator chamber. Once the pilot is off it cannot be relighted unless the gas flow is stopped or diverted from the incinerator. A bypass line consisting of 2-inch copper pipe with a valve on it, was installed between the dust filter and incinerator. Its main function was to divert the product gas flow to exhaust in case of emergencies.

The designers and supplier of the incinerator assembly, Lockhead-Haggerty of New Westminster, B.C., discovered that the air and product gas connections on the mixing venturi were wrongly made. The faulty piping was rectified by them and a new zero regulator was installed in the line replacing the existing ratio vale. Even after these changes the pilot on the incinerator could not be kept lighted. Present plans are to increase the speed of the gas turbo blower drive to increase the gas pressure going to the incinerator burner.

The top plate on the incinerator stack was modified by welding a skirt around it, so that rain water may not enter through the side openings and cause damage to the refractory.

2.5 Maintenance Work

The refractory lining of the conical portion at the bottom of the gasifier was found to be gradually wearing out on its inside. This had changed the cone angle which would affect the aerodynamics of the spouted bed. A new cone was cast at an angle of 50°. The refractory inside the cylindrical portion of the reactor was also patched up. It is severely cracked, and may need to be replaced in 1981-82.

Cleaning and maintenance work was performed on the tar condenser. One of the mild steel cooling plates which had corroded was removed. The exhaust fan on the product gas line was disassembled and the tarry deposit was completely cleaned from the housing and the blades.

2.6 Future Modifications

The following repair and modification jobs will need to be done on the pilot unit to further improve its operability.

(i) Change the refractory lining inside the gasifier

(ii) Improve the dust recycle system to allow long term operation. A new dust feeder is required.

(iii) Improve the tar condensation system by replacing the plate tar condenser by a double pipe cooler.

(iv) Design a system to minimize moisture in the product gas. Runs at low steam/coal ratios will be carried out.

(v) Improve the incinerator design.

(vi) Install pneumatic clamping system on coal feeder drum.

(vii) Install 3500 rpm motor on the exhaust fan for the product gas in place of 1800 rpm existing motor.

(viii) A ventilation study in the Chemical Engineering Building has recommended that Workmen's Compensation Board examine the coal laboratory, with the idea of specifying an electrostatic or other type of filter for the air over the gasifier plant.

3. EXPERIMENTAL

The details of a typical gasification run in the spouted bed pilot plant has been described earlier (2). During several runs the product gas was analysed for particulate matter and sulphur gases. To obtain the particulate loading and size distribution in the product gas, the Andersen Air Sampler was used. The product gas sample was continuously withdrawn downstream of the dust filter and allowed to flow through a water cooled condenser prior to its entry in the air sampler. A gas flow meter and a vacuum pump were used in the line to maintain the flow rate at 1 cfm. The use of an in-line condenser minimized condensation inside the Andersen Sampler, however, it did not eliminate the problem completely.

To further improve the results, after each run the air sampler was placed in an oven (≈ 150°F) for 24 hours to get rid of the condensed water. A low temperature in the drying oven was maintained to minimize the evaporation of low boiling hydrocarbons which may have deposited in the sampler.

A Varian gas chromatograph equipped with a flame photometric detector was used to determine the amount of sulphur gases present in the product gas. The conditions maintained during gas chromatographic analysis are listed below:

Column:	Carbopak BHT 100 6 ft. long, 1/8 inch teflon tube
Carrier Gas:	Nitrogen, 80 ml/min
Other Gases:	Hydrogen, 170 ml/min Oxygen, 20 ml/min Air, 20 ml/min
Column Temp.:	50°C
Injector Temp:	60-70°C
Transferline Temp.:	60°C

The performance of the detector was calibrated using standard gas samples prepared by taking known volumes of pure H_2S and SO_2 gases in air. During a gasification run the product gas samples were manually taken in a gas-tight syringe and injected in the GC. The analysis was continued during the entire run at regular intervals.

A few runs were made to assess the use of a char bed formed from the coal instead of an air inert gravel bed. For these runs 14 kg. of non-caking coal (0.4-0.8 mm in size) was initially charged in the spouted bed. One run was made to determine the effect of high surface moisture in the coal on the operation of pilot plant. For this run 4% additional water was added to Forestburg coal which already contains about 23% moisture.

The solids collected in the first cyclone were recycled during several runs to study the effect of char recycle on the overall carbon conversion efficiency. The dust recycling was not successful in all the runs due to numerous problems with the dust feeder system.

Besides the routine runs, two extended runs were also made which lasted for 11 and 14 hours. These runs were limited only by the amount of available coal, and were shut down voluntarily.

4. RESULTS AND DISCUSSION

4.1 Gaseous Impurities

Sulphurous species in the gas were analysed on a Gas Chromatograph equipped with a flame photometric detector. The concentrations of H_2S and SO_2 in the product gas varied considerably during any particular run. The maximum values of these concentrations are shown in Table 1. The typical values are 115-160 ppm H_2S and 20-80 ppm SO_2. Only trace amounts of COS were detected in a few samples. Sulphur in the dry gas amounts to less than 20% of that entering with the coal. About 13-33% of the sulphur goes with the cyclone char. The unaccounted sulphur presumably remains with the condensate as the gas is cooled, although this has not yet been confirmed. Some consideration is being given to methods of completing the sulphur balance.

Particulates in the gas after cyclones and knock-out drums are less than 0.8 grams/m^3 (0.35 grains/scf). Particulates below 2μ in size were primarily tar-like and analysed 90% carbon, whereas those over 2μ were char containing about 45% carbon. The small particle size of the tar suggests that complete tar removal will be difficult, without an electrostatic precipitator.

4.2 Recycle of Cyclone Char

Because of the large dust carryover and its effect on carbon conversion, some runs have been carried out with product from the first cyclone being recycled to the gasifier. Table 2 summarizes results for sub-bituminous (Forestburg) and bituminous (Sukunka) coals. At fixed air rate, when recycle of char is carried out the net coal feed rate is reduced. With marginal changes in gas calorific value, a marked efficiency increase occurs over once-through operation. The mass steam decomposition rate is slightly higher when operating on fresh coal feed. The net char production rate of course decreases when recycle is used.

Operation with dust recycle is not without problems. During start-up wet gases condense in the cold cyclone and the char tends to agglomerate. This was alleviated to some extent by external heating coils and nitrogen bleed around the cyclone discharge. Problems in maintaining the recycle feed system (based on a rotary valve feeder of our own design) in operation for more than four hours have precluded sustained runs with char recycle. A new char feeding system is being developed.

4.3 Char Versus Inert Bed

A few runs were carried out in which the inert gravel bed was replaced by a char bed formed by partial combustion of sub-bituminous coal. Table 3 compares the data in these two modes. With the reactive char bed, the particle size under steady state of 0.4-0.8 mm

was considerably lower than the 2.06 mm gravel size. This dictated lower superficial velocities of 0.6-1 m/s compared to 2 m/s typical of inert bed operation. At the same time carryover was much higher with the char bed, the cyclone product is high in carbon and even with recycle of 8.9 kg/hr of char, little advantage compared to operation with the inert bed is evident.

The primary advantage of operating with a char bed is that no material in addition to the coal feed is required. The reactive nature of the char obviously makes operation more difficult, and its has not yet been tested with caking coals. The inert bed has the advantage of allowing selection of an optimum particle size for spouting which remains constant. Some difficulties may exist with low fusion temperature of constituents in the gravel, and some agglomeration of the gravel has been observed during shut down when the coal feed is stopped. Consideration is being given to other inert materials.

4.4 High Surface Moisture Coal

Run No. 41 was made using Forestburg coal with 27% total moisture. Forestburg coal contains about 23% moisture, the balance was made up by adding water to it. Because of high surface moisture some difficulty was encountered in feeding the coal and the feed rate was much lower at 26 kg/hr as compared to 40-65 kg/hr during other runs with Forestburg coal. The values of air/coal ratio and steam/coal ratio were both higher for this run while the gas calorific value was low. The data is shown in Table 4.

The existing feed system would have to be modified if further work is to be undertaken with coals of high surface moisture.

4.5 Extended Runs

Two extended runs (Run Nos. 42 and 43) were made which lasted for 14 and 11 hours. Both these runs using sub-bituminous (Forestburg) coal went quite smoothly and no problem was encountered in the operation of pilot plant. As stated above, the runs were shut down when available coal supplies ran out, not from any operating difficulty. The data from these runs are plotted in Figure 1 as a function of time. For the sake of comparison data from the earlier long runs, No. 27 with Forestburg coal lasting 8.4 hours and No. 26 with Coleman coal lasting 5.8 hours, are also plotted in a similar fashion in Figure 2. Vertical dotted lines on these figures indicate the change of coal feed drum. Comparison of Figures 1 and 2 clearly suggests that the performance of the spouted bed gasifier is quite reproducible over the last two years.

Operating variables such as air/coal ratio and steam/coal ratio were purposely varied during Run No. 42, to see their effect on the gasifier performance. In general use of air/coal ratio up to 3.5 based on dry coal, gave good quality gas with an average

heating value of 4.0 MJ/m^3. The steam/coal ratio influences the H_2/CO distribution in the gas to a certain extent. However, since heating values of H_2 and CO are almost identical, it did not make any difference in the heating value of the product gas.

Complete data for all the gasification runs (Nos. 29 to 43) performed during the year 1980-81, as well as Run Nos. 26 and 27 which were the long runs during the last year (1979-80) are shown in Table 5.

5. PERSONNEL

In July Dr. S.K. Foong who had designed and operated the gasification unit left the project. He was replaced in mid-December by Dr. C.B. Prakash who had carried out the sulphur and particulate study in May-July. During the period August - mid-December operations were carried on at a reduced level under G. Cheng with the temporary assistance of Nguyen Quoi. Long continuous runs are still difficult to manage as two people are required at all times for safe operation of the gasifier.

6. REPORTS AND PAPERS

Two papers, Coal Gasification in a Spouted Bed: Pilot Plant and Experimentation and : Results and Interpretation were presented at the CANMET Seminar, Coal Gasification Research and Development in Ottawa October 2 and 3, 1980.

A paper Spouted Bed Gasification of Western Canadian Coals was presented at the 30th Can. Chem. Eng. Conference, Edmonton, October 19-22, 1980. It is preprinted in the conference proceedings Vol. IV p. 1199-1208, and has been accepted for publication in the Canadian Journal of Chemical Engineering.

A paper entitled Gasification of Coal in a Spouted Bed has been prepared for an Institute of Gas Technology Symposium, Advances in Coal Utilization Technology IV, April 20-24, 1981 Denver.

7. BUDGET

In Table 6, proposed and actual expenditures for 1980-81 are compared. The project was within its overall budget, however it was found necessary to divert some money from salaries into supplies and equipment. Coal preparation was done with our own labour at B.C. Research with no charge for use of their facilities.

8. FUTURE WORK

Planned experimental work for 1981-82 is described in the appended Work Statement Fiscal Year 1981-82. Details of required equipment modifications and upgrading were described in section 2.6 of this report.

References

1. A.P. Watkinson, J. Foong and G. Cheng, "Spouted Bed Gasification of Western Canadian Coals - Final Report 1978-79", DSS Contract OlSU 23440-7-9073/II June 1979.

2. A.P. Watkinson, S.K. Foong and G. Cheng, "Spouted Bed Gasification of Western Canadian Coals - Final Report 1979-80", DSS Contract 08SU 23440-8-011 Contract OSU79-00065, May 1980.

Acknowledgement

The contribution of Luscar Ltd., Coleman Colliery and B.P. Canada who provided the coal is gratefully acknowledged. B.C. Research allowed free use of their crushing and screening facilities. Maintenance and fabrication were done by the Chemical Engineering Department workshop personnel.

Work Statement FY 80/81

1. Objectives

1. Determine effect of recycle of carryover product on gas quality, steady state carryover composition and operational stability

2. Evaluate operation with char bed as opposed to inert gravel bed

3. Determine maximum moisture content of coal feed for gasification

4. Assess composition of minor constituents in gas-sulphur, tar and dust

5. Assess mathematical models for scale up.

Major Tasks

1. Recycle cyclone-catch solids to gasifier through separate feeder.
   Test with Forestburg and Sukunka coals
   1 April - 31 May

2. Install internal cyclone in freeboard of gasifier to test internal recycle of bed carryover. Tests with Forestburg and Sukunka coals.
   1 June - 30 July*

3. Set up analytical equipment for sulphur species in gas, solvent fractionation scheme to characterize tars and aerosol counting (sizing apparatus for dust. Monitor several typical runs.
   1 April 80 - 28 Feb.

4. Prepare char bed to replace inert gravel bed. Test under room temperature, spouting conditions for coal/char mixtures
   1 Aug* - 30 Aug

5. Gasifier trials with char bed using Forestburg, Coleman and Sukunka coals
   1 Sept - 31 Oct

6. Effect of coal moisture. Operate with same H_2O/coal ratio by increasing moisture content of coal and decreasing applied steam. Tests with Forestburg, Sukunka and Coleman coals.
   1 Nov - 31 Dec

Continued....

7. Carry out extended trials under optimum condition of bed material (gravel vs char), recycle of carryover (internal cyclone vas external), moisture content of coal, feed location, particle size, steam injection location from 1979-80 and 1980-81 conditions.
   1 Jan - 28 Feb 1981

8. Assess and improve mathematical model for scale-up. Cost a full scale gasifier plant.
   1 April '80 - 31 Mar '

9. Prepare final reports — 1 March - 31 March 198

Appendix 2

Work Statement 1981-82

Objectives

1. Extend range of coals gasified to provide broader data bank on behaviour of Western Canadian coals.
2. Compare spouted bed gasifier with fluidized bed gasifier.
3. Obtain in-bed gas composition and temperature profiles for use in mathematical model.
4. Extend mathematical model to predict gas composition as function of operating and design variables.
5. Provide further data as required for gasifier scale-up.

Major Tasks

1.	Design and test in-bed sampling rig for use in standard gasification tests.	1 Apr-1 Nov
2.	Revamp off-gas burner, dust recycle system and gas cooler. Design fluidization gas distributor.	1 Apr-31 May
3.	Install fluidized bed distributor and operate gasifier in fluidized mode with Forestburg and Sunkunka coals.	15 May-31 July
4.	Operate spouted bed gasifier with Crowsnest metallurgical coal feed.	15 Aug-15 Oct
5.	Operate spouted bed gasifier with Byron Creek thermal coal feed.	16 Oct-30 Nov
6.	Operate spouted bed gasifier with Alberta Roselyn coal.	1 Dec-31 Jan
7.	Operate spouted bed gasifier with Saskatchewan lignite.	1 Feb-31 Mar
8.	Run in-bed gas composition measurements.	1 Nov-31 Mar
9.	Improve gasifier mathematical model.	1 Apr-31 Mar
10.	Provide data as needed for scale-up.	1 Apr-31 Mar
11.	Prepare final report.	1 Mar-31 Mar

47 0782

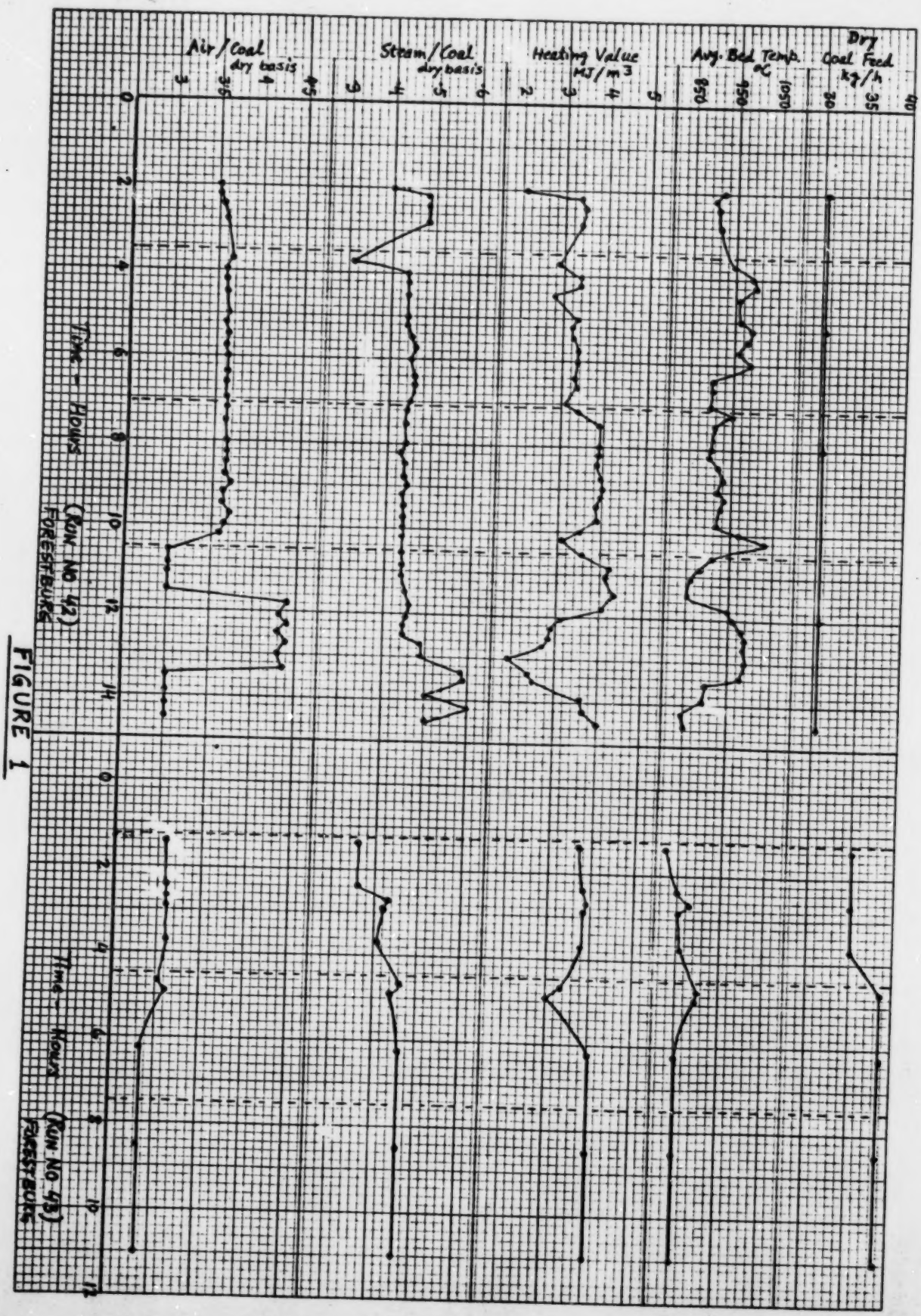
Air/Coal dry basis
Steam/Coal dry basis
Heating Value MJ/m³
Avg. Bed Temp. °C
Dry Coal Feed kg/h
Time - Hours (Run No 42) Forestburg
Time - Hours (Run No 43) Forestburg

FIGURE 1

K+E 10 X 10 TO THE INCH
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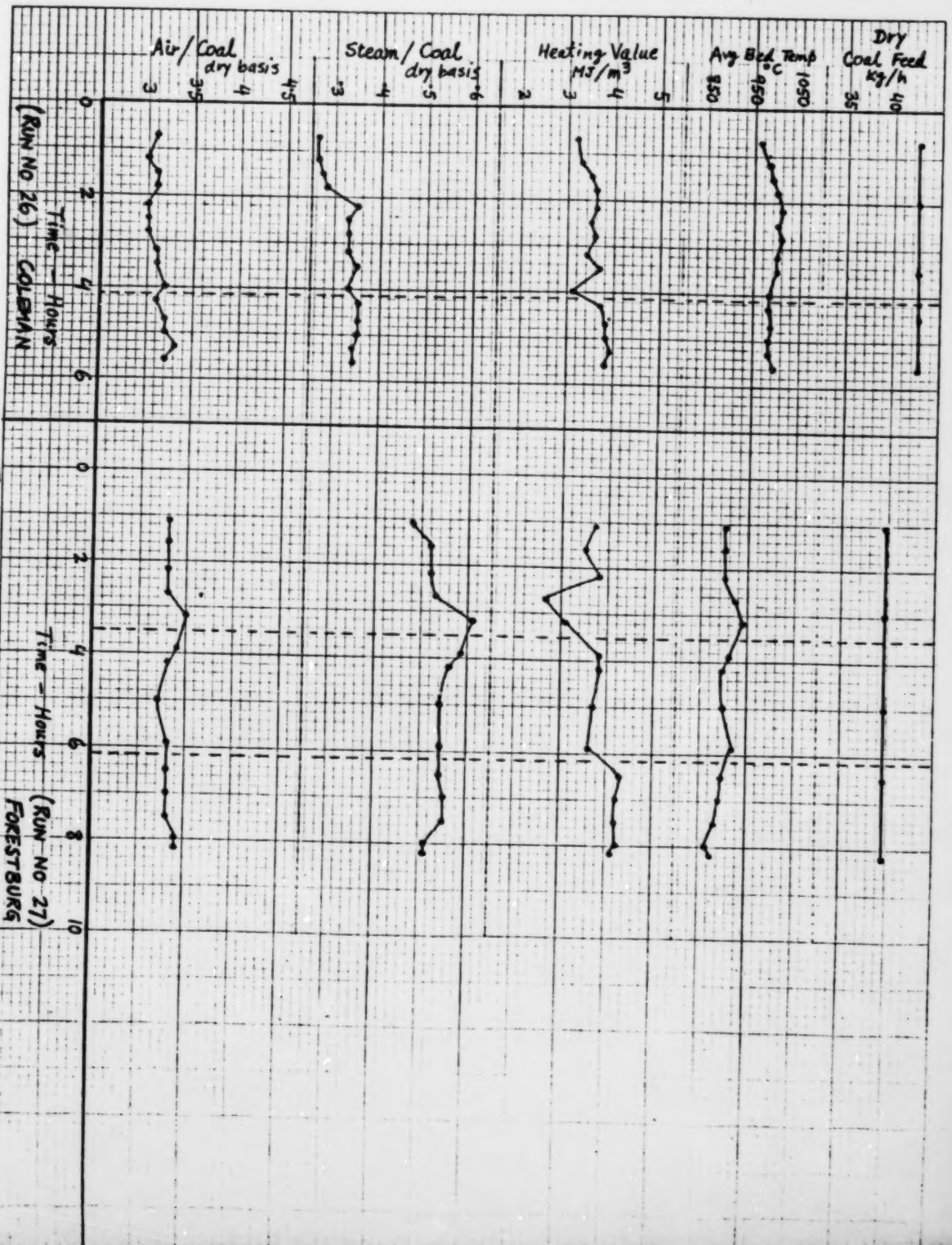

FIGURE 2

TABLE 1: SULPHUR DISTRIBUTION

Coal	Concentration in Gas (ppm) H_2S	SO_2	S in Gas / S in Coal Feed (%)	S in Char / S in Coal Feed (%)
Sub-bituminous				
Forestburg	151	80	18.9	16.7
	160	69	17.8	14.8
Bituminous				
Sukunka	125	55	17.7	33.7
Coleman	115	18	10.6	
	76	21	8.4	13.7

TABLE 2: OPERATION WITH CHAR RECYCLE

Coal	Sub-bituminous (Forestburg)		Bituminous (Sukunka)	
Dry Coal Feed (kg/h)	39	33.7	41.3	34.5
Char Recycle Feed (kg/h)	0.0	8.9	0.0	12.2
Air (kg/h)	132	127	124	134
Steam (kg/h)	20.0	10.4	10.9	12.5
Air/Coal	3.38	3.78	3.0	3.8
Gas H.V. (MJ/m^3)	4.2	4.2	3.28	3.08
Gas Yield (SCM/kg Coal)	4.46	4.45	3.0	3.5
Cold Gas Efficiency (%)	62	68	30	34.3
Steam Decomposition (%)	55	65	45	39
Net Char Production (kg/h)	5.6	3.9	12.6	5.7
Char Composition % Ash	33.4	25.9		14.3
Run No.	27	29	15	30

TABLE 3: INERT BED VERSUS CHAR BED*

Bed Material				
Initial Bed Wt. (kg)	45	14	14	14
Coal Fed Rate (kg/h)	30.5	29.6	36.2	34.9
Air Rate (kg/h)	93	62.8	96.7	54.5
Steam Rate (kg/h)	15.3	10.2	12.1	10.7
Cyclone Char Recycle (kg/h)				8.9
Net Char Rate (kg/h)	3.34	10.6	7.8	3.2
Char Composition % Ash	54.8	21.7	21.0	21.7
Gas Yield m^3/kg Coal	3.34	2.38	2.76	1.70
Gas H.V. MJ/m^3	3.93	3.20	3.95	3.37
Gas Velocity (m/s)	2.0	0.7	1.1	0.6
Hot Gas Efficiency	77.3	47	57	32
Bed Particle Size (mm)	2.08	0.41		0.75
Run No.	42(3)	39(1)	40	38

* Forestburg Coal

TABLE 4: OPERATION WITH HIGH SURFACE MOISTURE COAL

Coal Type	Forestburg	Forestburg
% Moisture	23.5	27.1
Dry Coal Feed (kg/h)	30.5	19.0
Air/Coal, dry basis	3.1	4.9
Steam/Coal, dry basis	0.51	0.81
Net Char Production (kg/h)	3.3	2.5
Gas H.V. (MJ/m^3)	3.9	2.1
Gas Yield (SCM/kg Coal)	3.4	4.6
Hot Gas Efficiency, %	77.3	65.0
Char Composition % Ash	45.2	38.8
Run No.	42(3)	41

TABLE 5: SUMMARY OF GASIFICATION OPERATING CONDITIONS AND RESULTS

Run No.	Duration of Run 'h'	Coal Type	Coal Size mm	Moisture in Coal %	Coal Feed Rate, kg/h Wet	Coal Feed Rate, kg/h Dry	Air/Coal dry basis	Steam/Coal dry basis	Cyclone Catch kg/h	Cyclone Catch % Ash	Cyclone Catch % C	Tar Yield kg/kg Coal % dry basis	Gas Yield m^3/kg Coal dry basis	Gross Heating Value MJ/m^3	Thermal Efficiency Hot Gas %	Average Bed Temp. °C	Product Gas Analysis Vt Dry Basis H_2	CO	CO_2	CH_4	N_2	Steam Decomposed %	Material Unaccounted %
26	5.8	Coleman	1.24	3.0	44.1	42.7	3.21	0.35	18.5	18.7	81.3	0.32	3.41	3.82	57.7	987	14.7	12.3	11.9	1.5	59.6	46.9	2.1
27	8.4	Forestburg	2.06	23.5	54.7	41.8	3.18	0.52	6.0	52.8	47.2	0.36	3.73	4.17	79.3	876	16.5	13.6	14.2	1.4	54.3	52.2	2.9
28	2.2	Forestburg	2.06	23.5	66.6	49.4	2.77	0.31	7.7	36.8	63.2	0.12	3.09	4.05	63.7	837	13.7	15.4	12.2	1.3	57.0	46.8	4.5
29	3.4	Forestburg	2.06	23.5	64.2	33.8	3.76	0.31	3.9	44.9	55.1	0.08	4.18	4.13	86.0	853	13.6	16.9	11.3	1.2	57.0	63.0	2.9
30	3.1	Sukunka	2.06	1.2	38.2	37.7	3.50	0.33	5.7	14.3	85.7	0.25	3.40	3.00	49.6	965	11.0	9.1	13.4	1.5	65.0	37.8	7.9
31	2.0	Coleman	1.36	3.0	61.5	40.3	3.21	0.27	14.5	22.5	77.5	4.35	3.24	3.31	49.3	962	12.4	10.7	12.9	1.4	62.6	45.6	2.7
32	1.3	Coleman	1.52	3.0	39.0	37.8	3.34	0.31	14.7	23.6	76.4	0.0	3.38	3.34	52.3	977	12.5	10.9	13.0	1.3	62.3	45.1	2.6
33	4.4	Coleman	1.52	3.0	36.4	35.3	3.79	0.37	9.5	30.9	69.1	0.39	3.81	3.17	57.0	996	11.7	10.8	13.3	1.2	63.0	44.0	3.9
34	2.1	Sukunka	2.06	1.2	37.5	37.1	3.54	0.31	14.2	20.0	80.0	0.0	3.44	2.88	50.0	1031	10.7	10.2	13.5	1.0	64.6	37.1	3.5
35	1.0	Forestburg	2.06	23.5	37.9	29.0	4.31	0.35	4.7	27.0	73.0	0.0	4.29	3.06	73.4	895	8.8	14.2	13.0	0.8	63.2	39.6	1.4
36	2.0	Forestburg	2.06	23.5	46.2	35.3	3.37	0.52	4.0	64.8	35.2	1.22	3.37	2.65	55.9	957	9.1	11.2	15.1	0.4	64.0	25.7	3.8
* 38	2.5	Forestburg	2.06	23.5	45.6	34.9	1.66	0.31	3.2	21.7	78.3	0.03	1.70	3.14	29.0	684	2.5	6.0	17.2	2.4	61.9	23.4	15.2
* 39	4.5	Forestburg	2.06	23.5	43.2	33.1	2.15	0.31	10.6	20.0	80.0	1.06	2.38	3.83	47.1	708	5.9	7.8	16.5	2.6	57.2	41.9	5.3
* 40	3.3	Forestburg	2.06	23.5	47.3	36.2	2.69	0.34	7.8	18.9	81.1	0.72	2.93	3.70	57.3	822	3.6	12.3	14.2	1.5	58.4	42.5	4.6
41	2.9	Forestburg	2.06	27.1	26.1	19.0	4.95	0.81	2.5	38.8	61.2	0.0	4.56	2.06	65.0	907	6.7	8.4	15.6	0.6	68.7	20.5	3.0
42(1)	14.5	Forestburg	2.06	23.5	39.8	30.5	3.64	0.45	3.3	45.2	54.8	6.1	3.70	3.26	77.9	977	10.4	13.9	12.6	0.8	62.3	36.1	3.5
42(2)	14.5	Forestburg	2.06	23.5	39.8	30.5	3.66	0.45	3.3	45.2	54.8	6.5	3.92	3.74	87.8	919	12.3	15.2	11.3	1.0	60.2	44.6	2.5
42(3)	14.5	Forestburg	2.06	23.5	39.8	30.5	3.05	0.51	3.3	45.2	54.8	5.6	3.39	3.93	77.3	970	15.3	13.6	12.9	1.1	57.1	44.7	4.4
42(4)	14.5	Forestburg	2.06	23.5	39.8	30.5	4.36	0.49	3.3	45.2	54.8	7.1	4.26	2.84	79.0	980	9.8	12.6	13.1	0.8	63.7	33.0	3.0
43(1)	11.0	Forestburg	2.06	23.5	46.0	35.2	3.10	0.40	7.2	28.1	71.9	0.28	3.40	3.81	67.7	852	13.2	14.9	13.1	1.1	57.7	44.0	2.1
43 (2)	11.0	Forestburg	2.06	23.5	50.5	38.7	2.84	0.46	7.2	28.1	71.9	0.28	3.18	4.03	86.6	856	14.6	14.9	13.1	1.2	56.2	42.0	4.8

*Runs made with char bed

TABLE 6: BUDGET SUMMARY

		Proposed	Spent
A.	Wages, Salaries and Benefits	$49,555	$44,296.21
B.	Materials and Supplies	2,200	3,515.74
C.	Equipment	1,600	9,274.00
D.	Coal Preparation	5,000	2,496.10
E.	Travel	3,000	2,954.21
F.	Overhead at 30% of A and B, 2% of E	15,586.50	14,403.24
	Total	$76,941.50	$76,941.50